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The technical field of the invention is the optical recognition and detection of free forming-flat (surfaces, which are three-dimensional formed, thus not planar and/or. are flat). The optical detection will with a method performed, an apparatus the embodiment or implementing the method (working procedure) becomes also proposed.

The automatic inspection is an important aspect during the inexpensive quality control. A substantial question of the automatic visual (optical) inspection is thereby the examination of structured or unstructured (plan) surfaces. Beside flat surfaces on subject-matters however ever more steps the need of the examination of formed (not planar) surfaces into the foreground, whereby the examination presupposes a detection of this surface regarding its structure, its errors, its quality or quality. Such three-dimensional (3D) formed surfaces (here as "free forming-flat" referred) are to be scanned and taken up however very heavy optical, there the position from apparatuses to the detection of the surface of many factors, among other things the form of the surface depend. The apparatuses to the detection of the surface as digital image in an inspection system can be cameras or illumination.

Therefore object of the invention the receptacle of the surface is to be conditioned in such a way that surface regions of the target in a suitable manner received to become to be able, whereby bottom "suitable" certain optical defaults meant are like z. B. reflex-free or "in the gloss angle" or "in the scattered light", which is in the inspection technique common technical terms with meaning contents.

With the invention the achieved becomes if the illumination unit (existing from or several lighting devices) and the receiving unit (existing from or several image retainers) become independent spatial so adjusted over mechanical mechanisms that can become detected of the taking up unit (or the several cameras) the recorded image in the suitability predetermined for the photograph situation (claim 1). The uncommon socket of the claims is to give us the possibility to make after report of the corresponding state of the art, the corresponding adjustments of the claims. A corresponding request does not need to be contained in the first answer, it is natural. Bottom suitability is the default to be understood that a surface region z.

B. reflex-free to be shown is. Bottom suitability it is to be also understood that the surface region, z. B. in the gloss angle to be shown is. Also under the fact understood can become that the surface z. B. in the scattered light to be shown is.

Of the receiving unit the recorded images must become not necessarily with visible light recorded, "optical seizing" by free forming-flat detected likewise frequencies outside of the visible light, z. B. Infrared and ultraviolet rays, which by set forward radiation converters on the frequency reacted to become to be able, is sensitive for which the chip intended in the camera (the image retainer).

A complete free forming-flat (the surface of the three-dimensional formed surface) can become by building the surface regions up obtained, if the adjacent in each case ranges bottom the same condition (reflex-free, gloss angle, scattered light) became recorded.

Also the specimen, which carries the free forming-flat, can become in the space independent changed (claim 2), whereby it becomes so adjusted over a mechanical actuator that together with the positioning or several cameras and the positioning or several lighting devices one can take place the default of the corresponding recording, those essentially only the predetermined condition satisfied.

If several image retainers and several lighting devices become spatial so adjusted that they have a predetermined spatial distribution, then the invention speaks of a "photograph arrangement", which can contain also the predetermined adjusted spatial layer of the free forming-flat (claim 3).

For certain surface portions (surface regions) the entire free forming-flat can take place an individual in each case recording. The pieces of surface can become then in the computer assembled, in order a full-extent image of the whole surface too devoted (claim 4).

The invention understands the bottom before described "suitability" in reflex-free form, in form of a representation in the gloss angle or in the scattered light that the straight surface region which can be taken up is problem-specifically proper illuminated, so that its surface has those the default corresponding uniform luminance (claim 3).

With the invention process the free forming-flat of the object can be present as CAD data set (claim 7). It can become also from a sequence of images or Stereobildern gained.

A sequence of photograph arrangements, like defined above, will of the invention as a "photograph strategy" referred, in order to seize the whole surface optical (claim 5). Each photograph arrangement is started thereby individual adjusted and and after recording of the image the next photograph arrangement adjusted and started, to in the frame of the photograph strategy the entire free forming-flat - or the relevant range of it - with selected in

each case the "luminance" recorded for the problem is, for z. B. reflex-free or in the gloss angle or in the scattered light or similar.

The invention becomes subsequent supplemented on the basis several embodiments explained and.

Fig. 1 an illustrated overview embodiment, are simultaneous shown in which the control-engineering system (right image portion) and the mechanical system (left image portion).

Fig. 2a to Fig. 2C illustrate the sequences of reflectances at a 3D-Freiform-Objekt with different luminance.

Fig. 3a to Fig. 3c show with the reflectances of the Fig. 2 a too strong pronounced Gussnaht as error detail admission.

A Motoriksteuerung 40 is provided, those over a Motorikbus MT several positioning units 41a, 41b, 42, 43a, 43b heads for, those in each case an apparatus to the recording or illumination or the object with the free forming-flat 20 even inertial. The mechanical positioning units 41a, 41b the inertial cameras c1, Kn. The mechanical positioning units 43a, 43b the inertial lighting devices B1, Bn. The positioning device 42 carries the object, whose free forming-flat is to become 20 optical scanned, in order to examine it. The object 20 becomes in the following "photograph object" mentioned.

The before described positioning units have adjustment possibilities in up to six dimensions, in particular three or less spatial shift degrees of freedom and three or fewer direction degrees of freedom, defined by angles of rotation in the space. Everyone of the before circumscribed positioning units becomes driven over the described Motorikbus MT and has a "mechanical coupling" X the respective apparatus or object, which is it fixed associated. The mechanical coupling X is a multi-axle coupling of the respective positioning unit (robot).

(A) The photograph object 20 becomes with the positioning unit 42 spatial and adjusted in its alignment at the spatial position. The position, into which the photograph object with and the free forming-flat which can be noted which can be lit up can become brought, is arbitrary.
(B) Lighting devices B1, Bn ("n" stands for a general whole number same or large 1) become of the positioning units 43a, 43b carried. There is exemplarily two drawn of these positioning units. Both one, as well as three, four or five and several selected can become, with corresponding in each case equipped lighting device, whereby the number makes the system more complex, which can arrange illuminating the surface however more accurate. Also these positioning units 43a, 43b can have the three or less spatial shift degrees of freedom and the three or fewer direction degrees of freedom.
(C) On other positioning units 41a, 41b are cameras c1, Kn mounted, whereby is disposed on each positioning unit a camera in each case. Each camera can become thereby individual adjusted, also in the described above manner of the maximum three spatial degrees of

freedom (space position) and the maximum three direction degrees of freedom (solid angles or orientation), in order to take the already adjusted illuminations and the already adjusted free forming-flat 20 a corresponding recording position.

Each camera K, each illumination B and if necessary. also the surface 20 which can be noted single (individual) over the engine IC control 40 into "a photograph arrangement" brought can become, superordinately controlled by the strategy module 100, which lets a photograph strategy, an existing from several photograph arrangements created and the different "photograph arrangements" adjust to basis of input data successively over the engine IC control 40. So a whole surface can become 20 in a Bildauswertung 90, which becomes 80 fed of an image pickup VB, accumulated and evaluated. The mentioned sensor technology or image pickup 80 collects the data of the cameras, those over the video bus VB is received and transfers it into computer-readable form, in order to pass it on to the picture evaluation fig. 90.

A Parametrierungssteuerung 30 is provided, which makes the adjustment of internal parameters at the apparatuses or the surface which can be noted over an internal parameter bus IP. Like that it is possible to select with the cameras K a particular photograph optics Fokusierung, polarization state, to adjust diaphragm or similar which takes place over an internal parameter set. For the lighting device B the internal parameters can give the light intensity or the type of the illumination (directed, structured diffuse or polarized), to also controlled by an internal parameter set, which becomes adjusted over the IP bus. Also at the photograph object 20 internal parameters adjusted can become. In the fig as i.P. (internal parameters) exemplarily z know represented parameter of the photograph object 20. B. its temperature its.

The CAD data module 91 supplies 100 CAD data to the strategy module with. These data describe the object or the free forming-flat 20, so far it for the creation of a photograph strategy (existing from several photograph arrangements) necessary are.

An object modelling 92 can be provided, which supplies to the strategy module with 100 out different picture receiver views a gained 3D-Beschreibung, which becomes the creation of the photograph strategy used.

The strategy module 100 sketches a photograph strategy for the surface on the object 20, thus a sequence of photograph arrangements, on the basis of its input data which are started by the positioning devices 41a, 41b, 42, 43a, 43b. For this first certain from user inputs, which surface regions of the object 20 in which kinds of photograph (scattered light, etc., becomes) received to become to be supposed. From the geometric positions of the surface regions in the space and the knowledge of the degrees of freedom of the illumination units Bi and receiving units AI as well as the positioning unit 42 for the photograph object, which can be taken up, using the physical laws to illumination and optical image a sequence is passed on

by suitable photograph arrangements calculated and at Motoriksteuerung 40 and parameter control.

The strategy module 100 knows also data from the image quality/image content default 94 obtained. These data can originate from the current photograph situation, and have already here on the photograph strategy reaction. Thus z can. B. an image sharpness lacking or a wrong lighting situation to be readjusted, after type of a closed loop. Also CAD data of the object, which the creation of the photograph strategy used to become, can become later changed.

In the already mentioned Bildauswertung 90 test tasks can be implemented, z. B. a surface testing, a measurement or a recognition of a certain characteristic range or error. The examination made with of the image retainers the c_1, K_n supplied screen window, or at an overall image of the free forming-flat composite from several screen windows. The results obtained over the evaluation 90 can be passed on at an external action module 110, which can likewise feed feeding back into the strategy module 100.

The sequences of illuminations different type of a 3D-Freiform-Objektes in shape of a coffee pot is in the Fig. 2a to 2C and a cutout from it as error detail admission in the Fig. 3a to 3c shown. In each case the Fig. 2a and 3a as well as the Fig. 2b and 3b as well as the Fig. 2C and 3c belong together regarding the light intensity, in which them received are. The pair of figures "A" is darkest, most brightly is the pair of figures "C" imaged. Significant one is to be seen that due to reflectances 24, 22, 23 on the surface of the coffee pot 20 of not all surface portions simultaneous with a camera and a lighting constellation received to become to be able, if an uniform illuminated image in a selected "suitability" (z. B. reflex-free) obtained will is. The bright areas 24 in Fig. 2a can become by an intelligent observer human nature distinguished of damages or Herstellungsfehlern, an automated optical recognition however are able this high intelligence necessarily to apply and could not therefore the reflectances 24 in Fig. 2a as errors classify, just as an actual present error 21 in form of a present Gussnaht in the Fig. 3a to 3c to recognize would have been. This to strong pronounced Gussnaht can be illuminated by a suitable positioning of the illumination and the cameras over the strategy module 100 in several photograph arrangements in such a way that the represented bright reflexes 23, 22 close of the Gussnaht been void and an image in an uniform representation can become obtained, which contains the Herstellungsfehler, which are to be detected, as remaining irregularities only.

The Fig. 3a knows z. B. in several ranges scanned will head for, so that smaller in each case ranges in a certain lighting arrangement and a certain photograph arrangement scanned and stored to become, in order for it an other photograph arrangement and will likewise scan and will store and in the memory will then build an other, second range up adjacent to the first range.

As image retainers cameras with line receiver or with matrix sensor can become used. For the illumination all common light sources are suitable. For the positioning units handling systems can become used, which are sufficient for the described degrees of freedom.

With the described sequence of in the space fixed positions (the photograph arrangements) the surface testing becomes either at surface regions or at the whole surface possible, only based up-automated evaluation of a digital represented free forming-flat.

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1. Method or arrangement for optical seizing of free forming-flat (20), with that or with that

(A) an illumination unit, existing from or several lighting devices (B1, Bn) into a first spatial constellation (43a, 43b) a brought will, in order to light up the free forming-flat (20);
(B) a receiving unit, existing from or several image retainers (c1, Kn) into a second spatial constellation (41a, 41b) a brought will, in order to note the free forming-flat (to 20), illuminated from the first spatial constellation, optical (VB, 80).

in such a way 2.Verfahren or arrangement according to claim 1, whereby the free forming-flat (20) or it supporting photograph object becomes into a space situation of brought (42), those to the first and second constellation of the illumination unit and receiving unit (B1, Bn, c1, Kn) that a problem-specifically predetermined surface recording is possible, at least uniform fits for a first surface region of the free forming-flat (20).

3. To reach method or arrangement after one of the preceding claims, whereby the first and second spatial constellation and the first space situation form a "photograph arrangement", in order the recording of a range (segment) of the free forming-flat (20) in an uniform luminance, in particular reflex-free, in the gloss angle, in the scattered light.

4.Verfahren or arrangement after one of the preceding claims, whereby the complete surface becomes the free forming-flat (20) by digital assembly of detected surface regions (segments) from a respective photograph arrangement composite.

5. Method or arrangement after one of the preceding claims, whereby a photograph strategy consists of several successively adjusted photograph arrangements, in particular out third and fourth or fifth and sixth constellation and associated second or third space situation, which become successively predetermined of a strategy module (100) (40, MT).

6.Verfahren or arrangement after one of the preceding claims, with that the adjustment of space situation and constellation over positioning devices (41a, 41b; 42; 43a, 43b) performed becomes, which permits to adjust several cartesian spatial degrees of freedom and several

spatial direction degrees of freedom.

7. Method or arrangement after one of the preceding claims, with which the data of the free forming-flat or the object, which carry the free forming-flat (20), by a data module (91, 92) the strategy module (100) to be course-fed, in particular with a feedback from recorded images (80, 90; VB1, VB2, VB) of the receiving unit (B1, Bn).

8.Verfahren or arrangement after one of the preceding claims, with which the illumination unit and the receiving unit are independently more adjustable (MT, 40), in particular all mechanisms or pickups (B1, Bn, c1, Kn) are more adjustable in the units individual in their space situation and their direction in the space.

9. Method or arrangement after one of the preceding claims, with which over a parameter bus (IPB) defaults of internal parameters (i.P.) are more adjustable in the image retainers (c1, Kn) or the illumination units (B1, Bn).

10. Method or arrangement after one of the preceding claims, whereby the receiving unit (c1, Kn) or exhibits several line orientated or matrix-oriented camera (s) with corresponding picture chip.

11-method or apparatus after one of the previous claims, with that optical seizing with frequencies in the visible light or outside of the visible light, like in the infrared spectral region or in the UV range made.

12. Method or apparatus according to claim 11, with that or with the volume range filters before the camera (c1, Kn), appropriate to the respective spectrum, disposed is; or the optical wavelengths of the illumination units (B1, Bn) on the sensitivity range of the cameras (c1, Kn) and/or. in it located picture chip converting filter provided is, which is disposed before the respective camera.

13. Method or apparatus after one of the previous claims, with that or with and/or. the strategy module (100) from it the supplied input data (91) over the property and/or form of the free forming-flat (20) a sequence of first/second, third/fourth and away-subsequent space constellation pairs of in each case illumination unit (B1, Bn) and receiving unit (c1, Kn) gives, those over a Motoriksteuerung (40MB) to the units (B1, Bn, c1, Kn) abandoned will, in order to implement it successively bottom creation of the first, second and away subsequent receiving area (segments or image regions) in video data form (VB).